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Shigeta

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(54) **POSITION DETECTING APPARATUS, AND LENS APPARATUS AND IMAGE PICKUP APPARATUS INCLUDING THE POSITION DETECTING APPARATUS**

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G01D 5/347 (2006.01)
G01B 11/14 (2006.01)
H04N 5/232 (2006.01)
G01D 5/244 (2006.01)

(52) **U.S. Cl.**
CPC ***G01D 5/34776*** (2013.01); ***G01B 11/14*** (2013.01); ***G01D 5/24461*** (2013.01); ***G01D 5/34792*** (2013.01); ***H04N 5/232*** (2013.01)

(58) **Field of Classification Search**
CPC .. G01D 5/347; G01D 5/3473; G01D 5/2455; G01D 5/2457; G01D 5/2497
USPC .... 250/231.13, 221, 214 R, 208.1; 341/11–13
See application file for complete search history.

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(57) **ABSTRACT**

A position detector, includes: a scale having pattern arrays formed in different cycles in a movement direction an obtaining unit which obtains signals in accordance with the pattern arrays; a first deriving unit which derives a temporal position of the scale relative to the obtaining unit based on the signals; a second deriving unit which derives a displacement amount of the scale relative to the obtaining unit based on one or more signals of the signals; and a determinates which determines a determined position of the scale relative to the obtaining unit based on the temporal position and the displacement amount, wherein the determinator determines the determined position based on a result of comparison between a difference between first and second temporal positions respectively calculated by the first and second deriving units at first and second positions and a displacement amount from the first position to the second position.

9 Claims, 9 Drawing Sheets

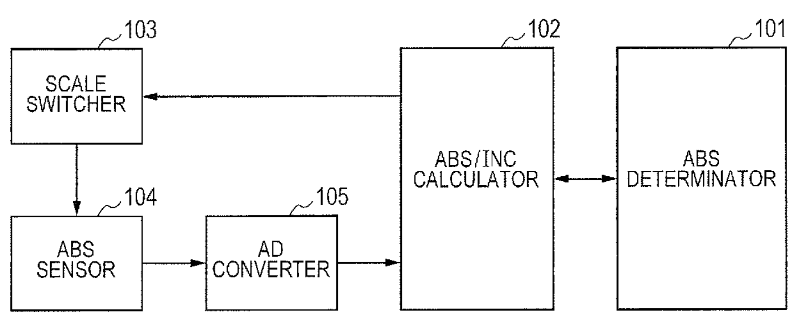


FIG. 1

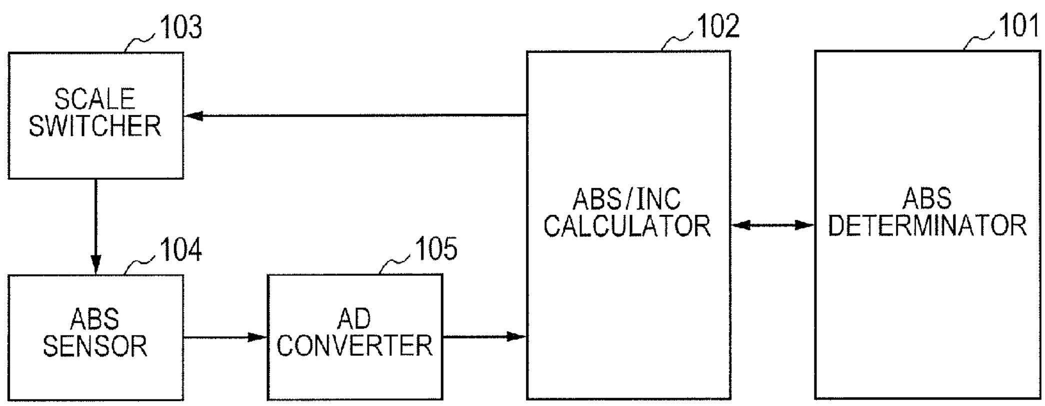

103
SCALE SWITCHER
102
ABS/INC CALCULATOR
101
ABS DETERMINATOR
104
ABS SENSOR
105
AD CONVERTER

FIG. 2

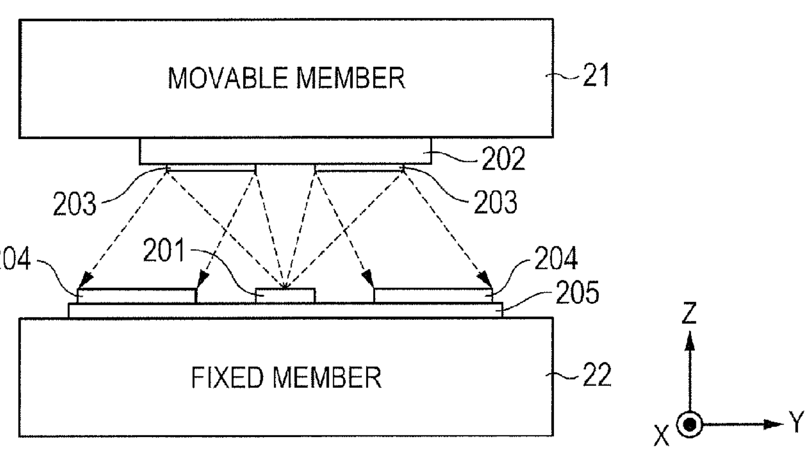

MOVABLE MEMBER
21
202
203
203
204
201
204
205
FIXED MEMBER
22
Z
X
Y

FIG. 3

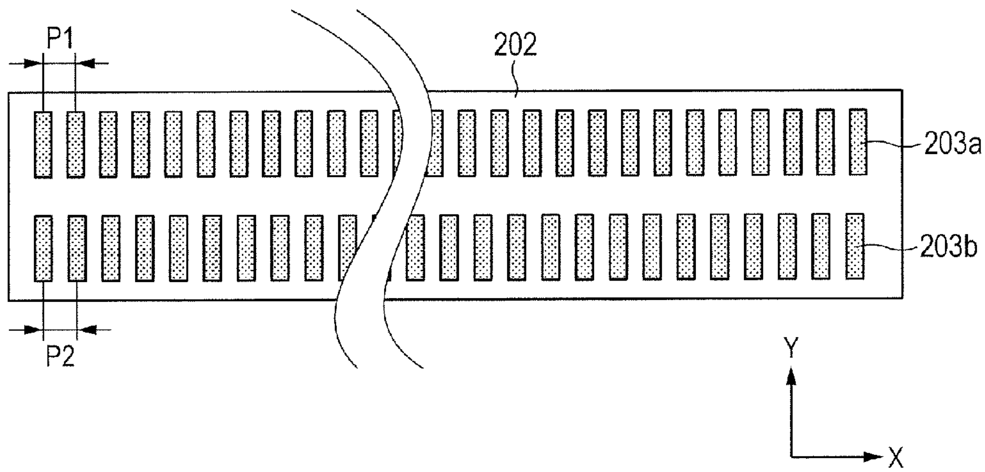

P1
202
203a
203b
P2
Y
X

FIG. 4

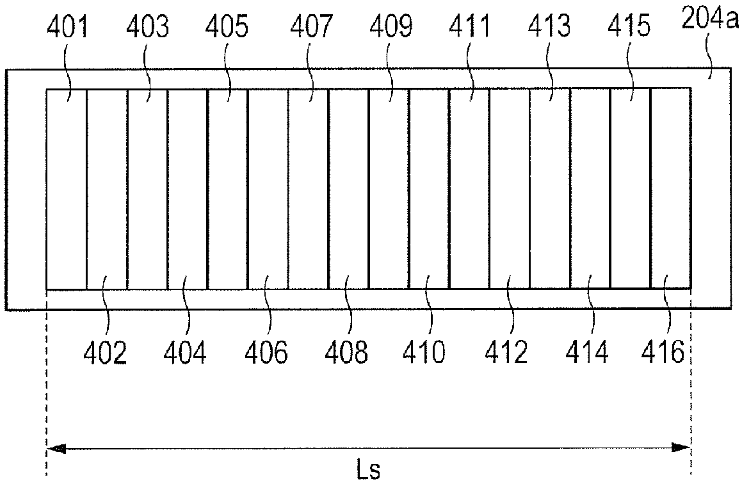

401
403
405
407
409
411
413
415
204a
402
404
406
408
410
412
414
416
Ls

FIG. 5

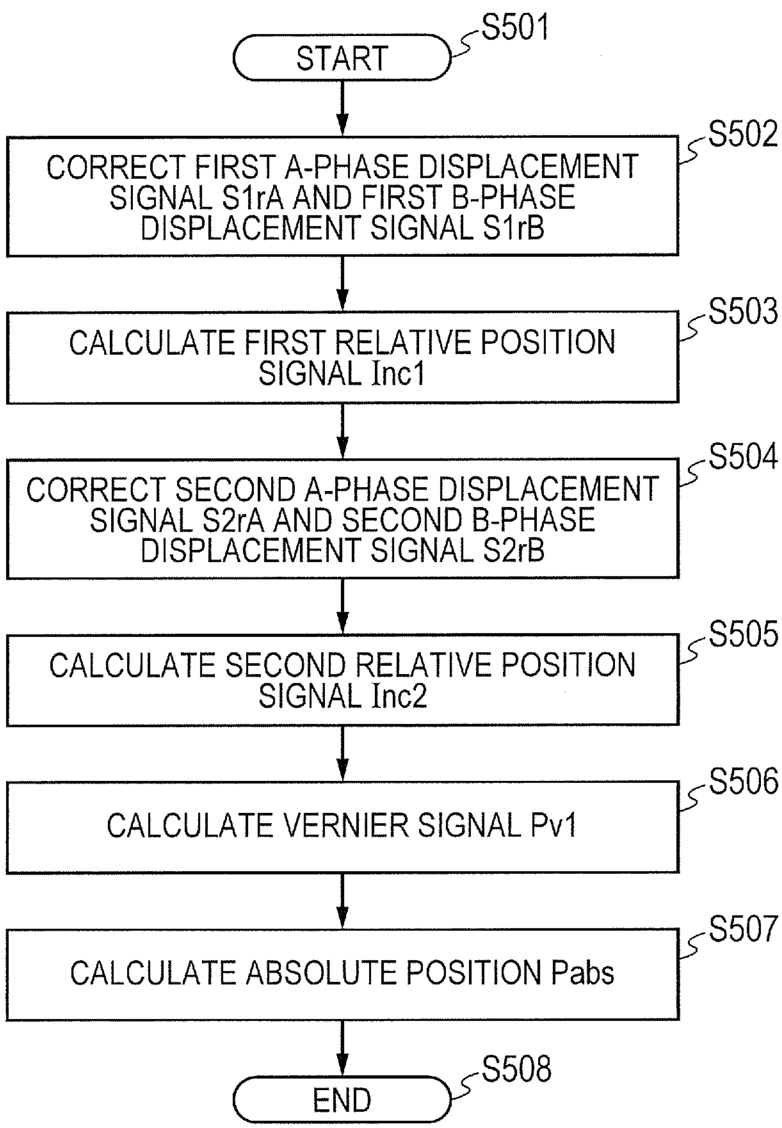

START
S501
CORRECT FIRST A-PHASE DISPLACEMENT SIGNAL S1rA AND FIRST B-PHASE DISPLACEMENT SIGNAL S1rB
S502
CALCULATE FIRST RELATIVE POSITION SIGNAL Inc1
S503
CORRECT SECOND A-PHASE DISPLACEMENT SIGNAL S2rA AND SECOND B-PHASE DISPLACEMENT SIGNAL S2rB
S504
CALCULATE SECOND RELATIVE POSITION SIGNAL Inc2
S505
CALCULATE VERNIER SIGNAL Pv1
S506
CALCULATE ABSOLUTE POSITION Pabs
S507
END
S508

FIG. 6A

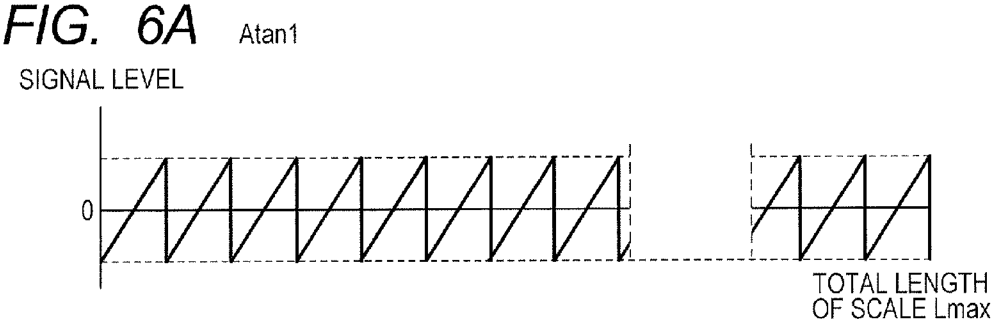


FIG. 6B

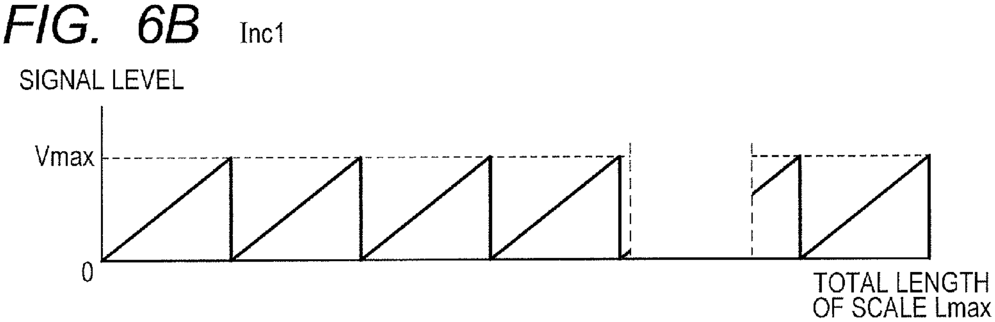


FIG. 6C

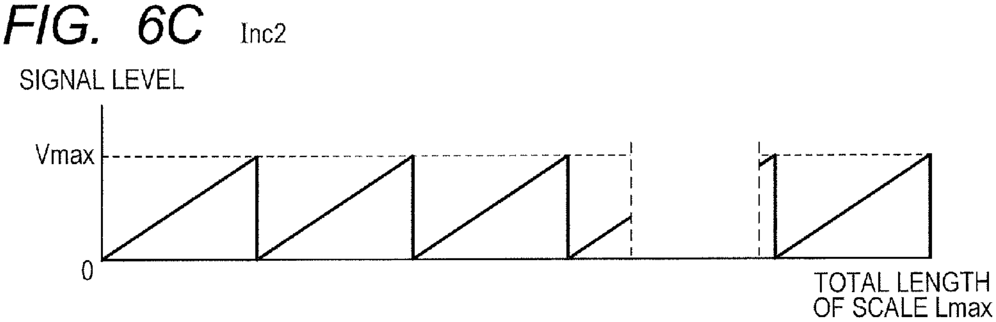


FIG. 6D

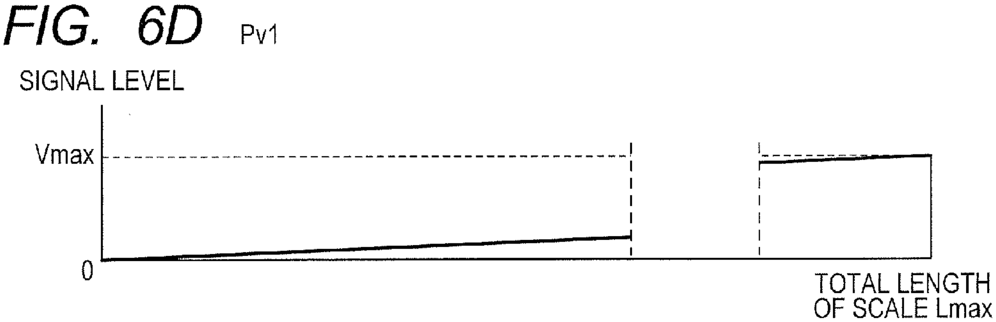


FIG. 7A

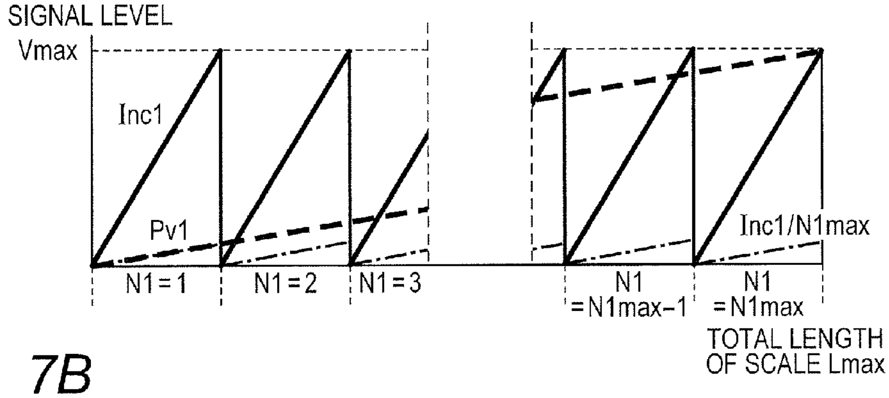


FIG. 7B

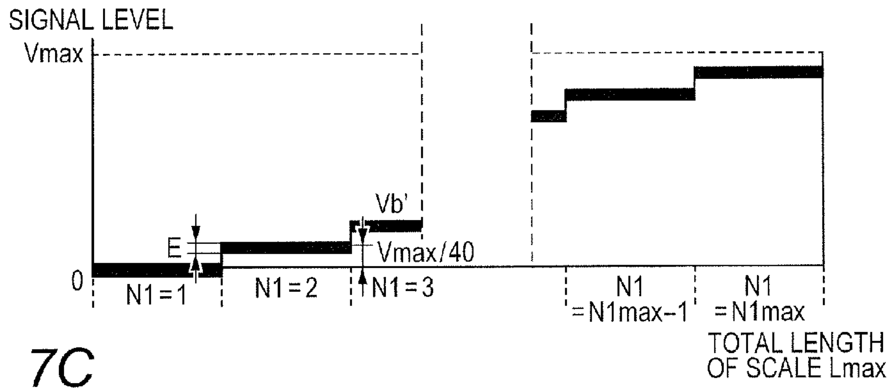


FIG. 7C

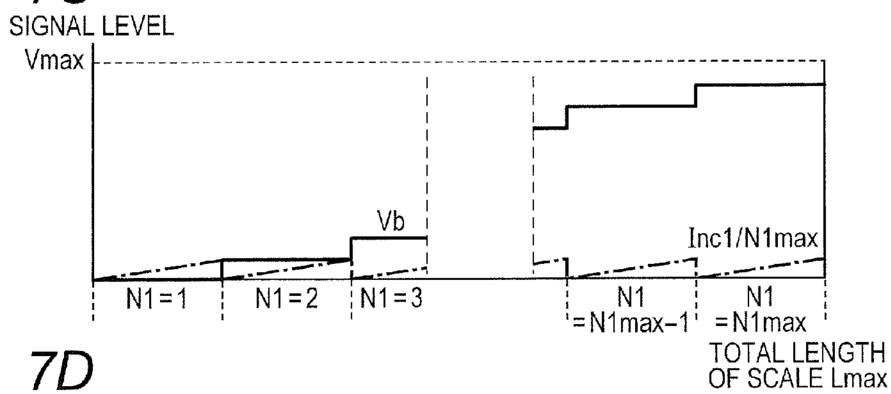


FIG. 7D

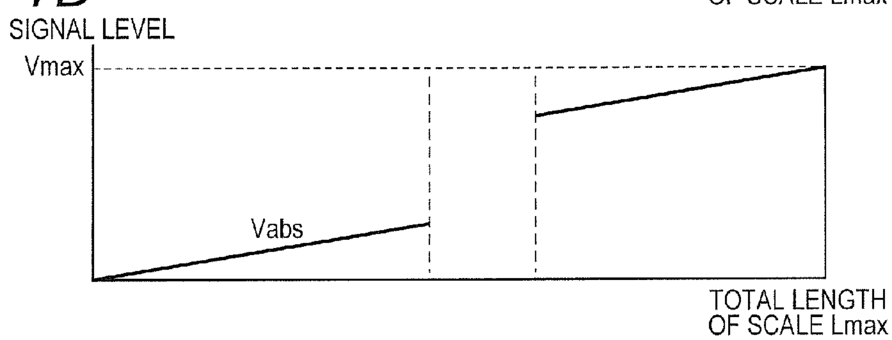


FIG. 8A

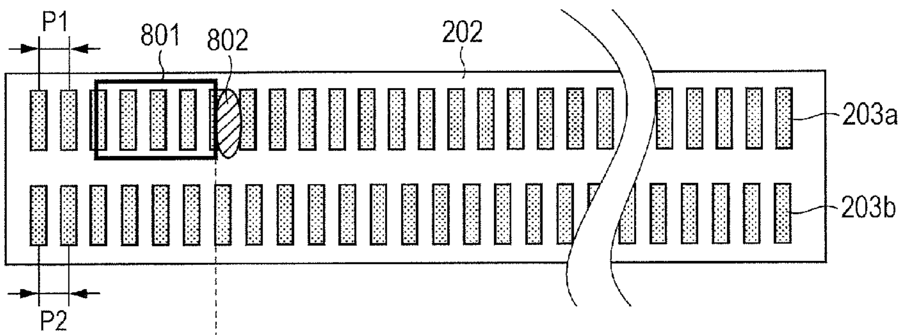


FIG. 8B

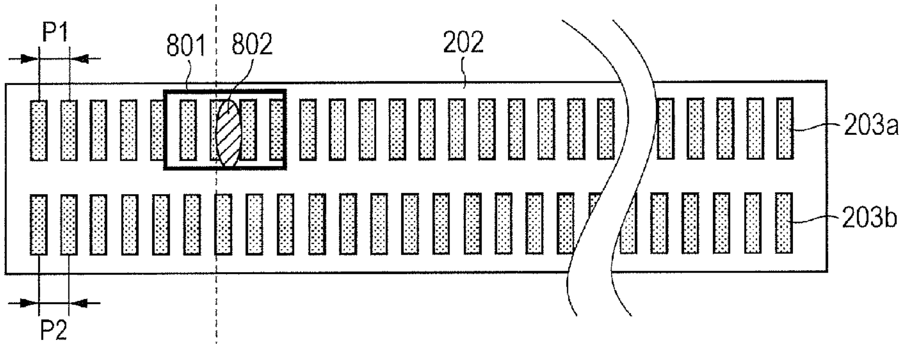


FIG. 8C

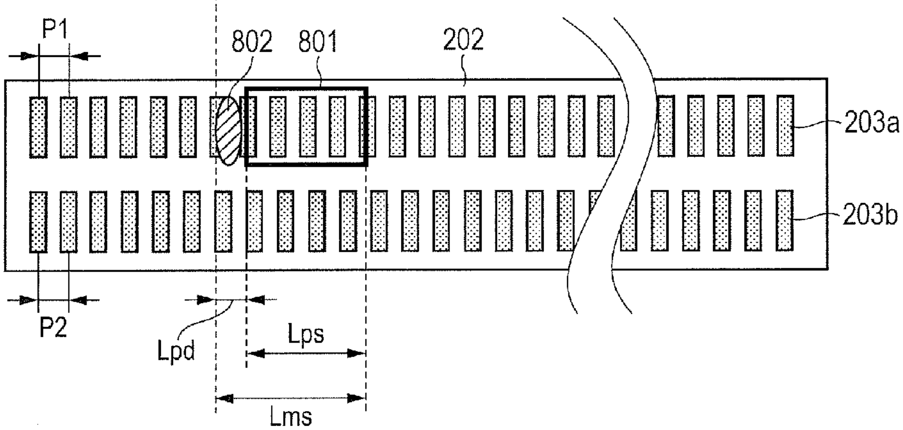


FIG. 9

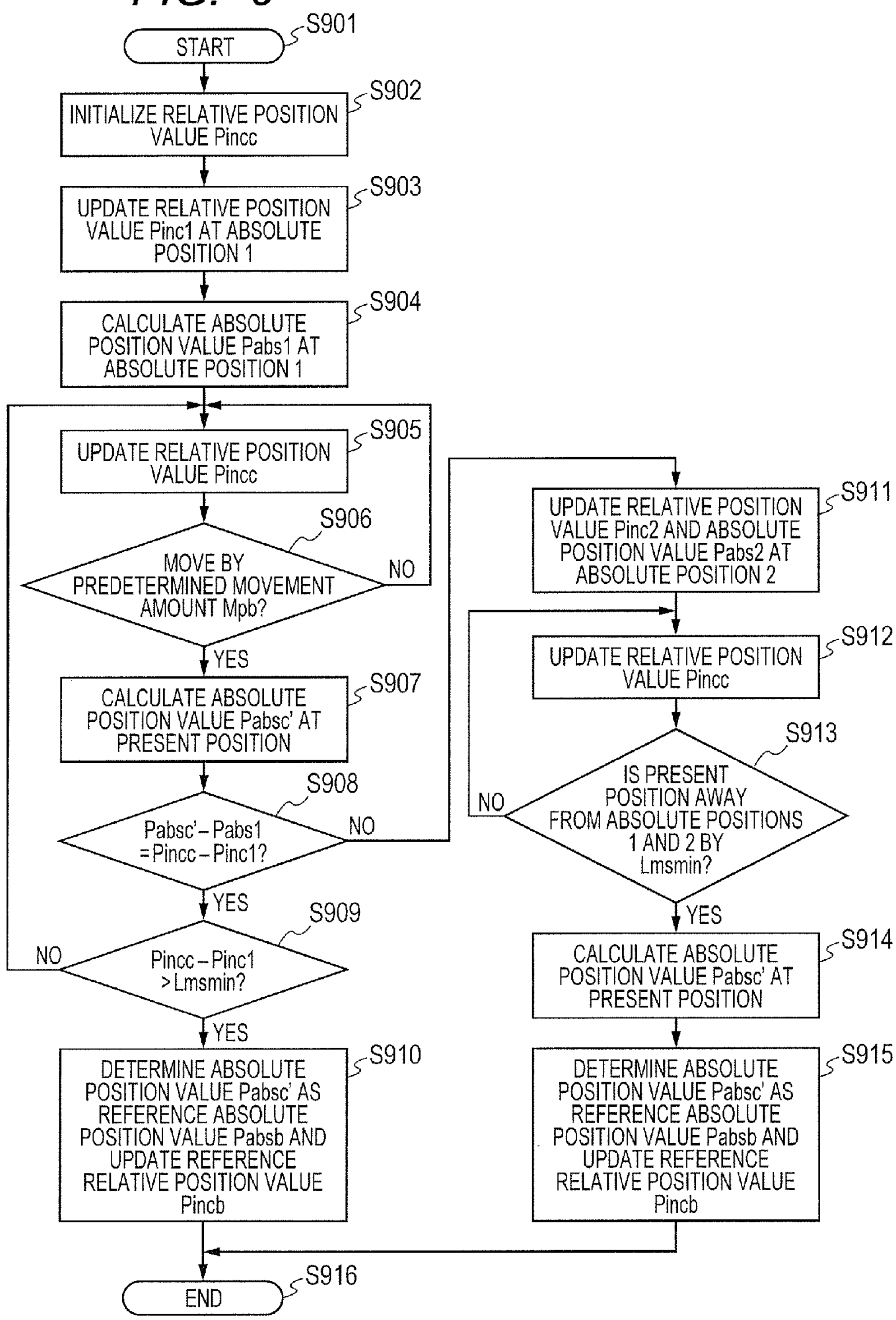

S901
START
S902
INITIALIZE RELATIVE POSITION VALUE Pincc
S903
UPDATE RELATIVE POSITION VALUE Pinc1 AT ABSOLUTE POSITION 1
S904
CALCULATE ABSOLUTE POSITION VALUE Pabs1 AT ABSOLUTE POSITION 1
S905
UPDATE RELATIVE POSITION VALUE Pincc
S906
MOVE BY PREDETERMINED MOVEMENT AMOUNT Mpb?
NO
YES
S907
CALCULATE ABSOLUTE POSITION VALUE Pabsc' AT PRESENT POSITION
S908
Pabsc'−Pabs1 =Pincc−Pinc1?
NO
YES
S909
Pincc−Pinc1 >Lmsmin?
NO
YES
S910
DETERMINE ABSOLUTE POSITION VALUE Pabsc' AS REFERENCE ABSOLUTE POSITION VALUE Pabsb AND UPDATE REFERENCE RELATIVE POSITION VALUE Pincb
S911
UPDATE RELATIVE POSITION VALUE Pinc2 AND ABSOLUTE POSITION VALUE Pabs2 AT ABSOLUTE POSITION 2
S912
UPDATE RELATIVE POSITION VALUE Pincc
S913
IS PRESENT POSITION AWAY FROM ABSOLUTE POSITIONS 1 AND 2 BY Lmsmin?
NO
YES
S914
CALCULATE ABSOLUTE POSITION VALUE Pabsc' AT PRESENT POSITION
S915
DETERMINE ABSOLUTE POSITION VALUE Pabsc' AS REFERENCE ABSOLUTE POSITION VALUE Pabsb AND UPDATE REFERENCE RELATIVE POSITION VALUE Pincb
S916
END

FIG. 10

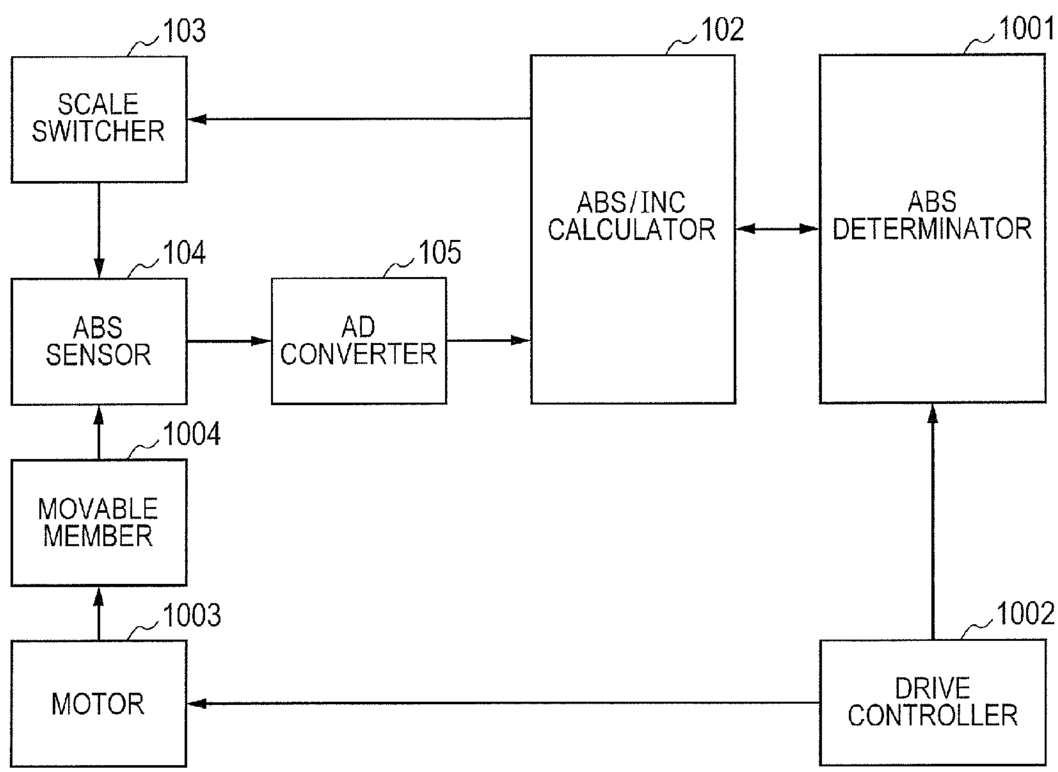
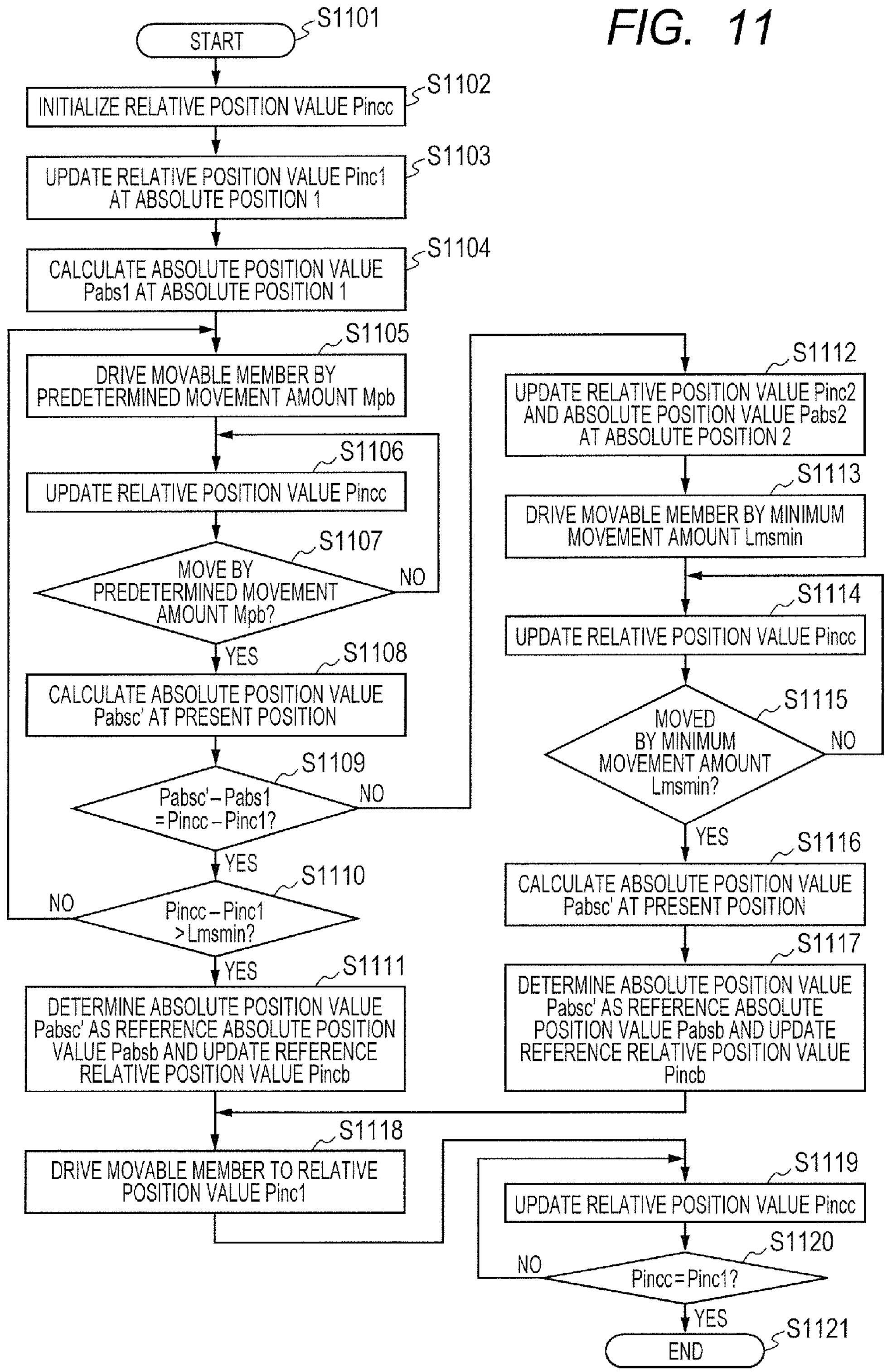

103
SCALE SWITCHER
102
ABS/INC CALCULATOR
1001
ABS DETERMINATOR
104
ABS SENSOR
105
AD CONVERTER
1004
MOVABLE MEMBER
1003
MOTOR
1002
DRIVE CONTROLLER

FIG. 11


START
S1101
INITIALIZE RELATIVE POSITION VALUE Pincc
S1102
UPDATE RELATIVE POSITION VALUE Pinc1 AT ABSOLUTE POSITION 1
S1103
CALCULATE ABSOLUTE POSITION VALUE Pabs1 AT ABSOLUTE POSITION 1
S1104
DRIVE MOVABLE MEMBER BY PREDETERMINED MOVEMENT AMOUNT Mpb
S1105
UPDATE RELATIVE POSITION VALUE Pincc
S1106
MOVE BY PREDETERMINED MOVEMENT AMOUNT Mpb?
S1107
NO
YES
CALCULATE ABSOLUTE POSITION VALUE Pabsc' AT PRESENT POSITION
S1108
Pabsc' − Pabs1 = Pincc − Pinc1?
S1109
NO
YES
Pincc − Pinc1 > Lmsmin?
S1110
NO
YES
DETERMINE ABSOLUTE POSITION VALUE Pabsc' AS REFERENCE ABSOLUTE POSITION VALUE Pabsb AND UPDATE REFERENCE RELATIVE POSITION VALUE Pincb
S1111
UPDATE RELATIVE POSITION VALUE Pinc2 AND ABSOLUTE POSITION VALUE Pabs2 AT ABSOLUTE POSITION 2
S1112
DRIVE MOVABLE MEMBER BY MINIMUM MOVEMENT AMOUNT Lmsmin
S1113
UPDATE RELATIVE POSITION VALUE Pincc
S1114
MOVED BY MINIMUM MOVEMENT AMOUNT Lmsmin?
S1115
NO
YES
CALCULATE ABSOLUTE POSITION VALUE Pabsc' AT PRESENT POSITION
S1116
DETERMINE ABSOLUTE POSITION VALUE Pabsc' AS REFERENCE ABSOLUTE POSITION VALUE Pabsb AND UPDATE REFERENCE RELATIVE POSITION VALUE Pincb
S1117
DRIVE MOVABLE MEMBER TO RELATIVE POSITION VALUE Pinc1
S1118
UPDATE RELATIVE POSITION VALUE Pincc
S1119
Pincc = Pinc1?
S1120
NO
YES
END
S1121

POSITION DETECTING APPARATUS, AND LENS APPARATUS AND IMAGE PICKUP APPARATUS INCLUDING THE POSITION DETECTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a position detecting apparatus configured to detect a position of a movable member, and to a lens apparatus and an image pickup apparatus including the position detecting apparatus.

2. Description of the Related Art

As an apparatus for measuring a distance of movement of an object, besides an incremental encoder for measuring a distance of relative movement, there is hitherto known an absolute encoder capable of detecting an absolute position.

Japanese Patent Application Laid-open No. H08-304113 discloses a Vernier type absolute encoder. The Vernier type absolute encoder disclosed in Japanese Patent Application Laid-open No. H08-304113 has a configuration including at least two grid patterns having different pitches on a track. Based on a slight shift between detected signals, which is generated due to a difference in pitch between the grid patterns, a position in a section over which the Vernier type absolute encoder circulates once is identified (hereinafter also referred to as "absolute position detection" or "absolute position calculation").

Japanese Patent Application Laid-open No. H05-45151 discloses timing of switching to an absolute counting operation in the Vernier type absolute encoder. The Vernier type absolute encoder has a configuration in which track patterns are formed at smaller pitches and at larger pitches. As the timing of switching to the absolute counting operation based on the tracks described above, when a speed is lowered to a speed at which erroneous detection does not occur in an incremental measurement at the smaller pitches, an operation of the Vernier type absolute encoder is switched to the absolute counting operation.

However, the absolute encoder disclosed in Japanese Patent Application Laid-open No. H08-304113 has the following problem. In the case where motes and scratches are present on a scale, an absolute position is calculated based on an erroneous detection signal. As a result, there arises a problem in that a correct absolute position cannot be calculated.

Further, the absolute encoder disclosed in Japanese Patent Application Laid-open No. H05-45151 has the following problem. In the case where motes and scratches are present on a scale at a position at which the speed is lowered so that erroneous detection does not occur in incremental measurement with fine pitches, an erroneous detection signal is detected. As a result, an absolute position is also calculated based on the erroneous detection signal.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a Vernier type position detecting apparatus having high reliability, which is capable of preventing erroneous absolute position calculation even in the case where motes and scratches are present on a track.

In order to achieve the above-mentioned object, a position detecting apparatus according to one embodiment of the present invention includes: a scale including a plurality of pattern arrays formed in different cycles in a movement direction; an obtaining unit configured to obtain a plurality of signals in accordance with the plurality of pattern arrays; a first deriving unit configured to derive a temporal position of the scale with respect to the obtaining unit, based on the plurality of signals; a second deriving unit configured to derive a displacement amount of the seals with respect to the obtaining unit based on one or more signals of the plurality of signals; and a determinator configured to determine a determined position of the scale with respect to the obtaining unit based on the temporal position and the displacement amount, wherein the determinator determines the determined position based on a result of comparison between a difference between a first temporal position calculated by the first deriving unit at a first position and a second temporal position calculated by the first deriving unit at a second position and a displacement amount derived by the second deriving unit from the first position to the second position.

According to one embodiment of the present invention, the position detecting apparatus having high reliability can be provided, which is capable of preventing erroneous absolute position calculation even in the case where motes and scratches are present on a track in the Vernier type position detecting apparatus.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a configuration block diagram according to a first embodiment of the present invention.

FIG. **2** is a sectional view of an ABS sensor.

FIG. **3** is a plan view of a scale unit.

FIG. **4** is a plan view of a light receiver.

FIG. **5** is a flowchart of absolute position calculation.

FIG. **6**A is a graph showing first and second relative position signals and a Vernier signal.

FIG. **6**B is a graph showing first and second relative position signals and a Vernier signal.

FIG. **6**C is a graph showing first and second relative position signals and a Vernier signal.

FIG. **6**D is a graph showing first and second relative position signals and a Vernier signal.

FIG. **7**A is a graph showing a waveform change in synchronism calculation.

FIG. **7**B is a graph showing a waveform change in synchronism calculation.

FIG. **7**C is a graph showing a waveform change in synchronism calculation.

FIG. **7**D is a graph showing a waveform change in synchronism calculation.

FIG. **8**A is a diagram illustrating a foreign matter on a scale and a pattern read area.

FIG. **8**B is a diagram illustrating a foreign matter on a scale and a pattern read area.

FIG. **8**C is a diagram illustrating a foreign matter on a scale and a pattern read area.

FIG. **9** is a flowchart of absolute position determination according to the first embodiment.

FIG. **10** is a configuration block diagram according to a second embodiment of the present invention.

FIG. **11** is a flowchart of absolute position determination according to the second embodiment.

DESCRIPTION OF THE EMBODIMENTS

In the following, exemplary embodiments of the present invention are described in detail with reference to the accompanying drawings.

First Embodiment

In the following, a position detecting apparatus according to a first embodiment of the present invention is described with reference to FIG. **1**.

FIG. **1** is a configuration block diagram according to the first embodiment. In FIG. **1**, an ABS/INC calculator **102** is a calculator (first deriving unit and second deriving unit) for calculating, based on a signal obtained from an ABS sensor **104**, an absolute position value Pabs (temporal position) that is a position (absolute position) calculated based on a signal obtained at a position of a movable member with respect to a predetermined reference position of a fixed member and a relative position value Pinc that is a displacement amount (relative position) from a certain position of the movable member with respect to the fixed member. A scale switcher **103** switches two types of signal outputs generated by two types of pattern arrays, which are sequentially output from the ABS sensor **104**. The ABS sensor (obtaining unit) **104** is an absolute position sensor for outputting a signal for calculating an absolute position of the movable member with respect to the fixed member. An internal configuration and the output signals of the ABS sensor **104** are described later. An AD converter **105** is configured to convert an analog signal output from the ABS sensor **104** into a digital signal. An ABS determinator **101** (determinator) is configured to determine a present absolute position Pabsc based on the absolute position value Pads and the relative position value Pinc calculated by the ABS/IRC calculator **102**. The ABS determinator **101** and the ABS/INC calculator **102** are configured in a single CPU, for example.

Next, an operation of this embodiment is described.

The ABS determinator **101** requests the ABS/INC calculator **102** to calculate the absolute position value Pabs. When receiving the absolute position calculation request from the ABS determinator **101**, the ABS/INC calculator **132** issues a command to the scale switcher **103** so that signals corresponding to the two types of pattern arrays successively are output from the ABS sensor **104**. The scale switcher **103** instructs the ABS sensor **104** to output two types of patterns of signals (described later) successively. The ABS sensor **104** outputs the signals corresponding to the two types of pattern arrays successively in accordance with the instruction from the scale switcher **103**. The signals corresponding to the two types of pattern arrays output from the ABS sensor **104** are converted into digital signals by the AD converter **105** and output to the ABS/INC calculator **102**. The ABS/INC calculator **102** calculates the absolute position value Pabs based on the signals corresponding to the two types of pattern arrays and outputs the absolute position value Pabs to the ABS determinator **101**.

On the other hand, the ABS/INC calculator **102** issues a command to the scale switcher **103** so that a signal corresponding to a pattern array required for calculating the relative position value Pinc is output from the ABS sensor **104**. The ABS/INC calculator **102** switches to the signal corresponding to the pattern array required for calculating the relative position value Pinc, and thereafter, calculates the relative position value Pinc based on the signal corresponding to the pattern array output from the AD converter **105** in the same way as the above and outputs the relative position value Pinc to the ABS determinator **101** periodically. The methods of calculating the absolute position and the relative position are described later. The ABS determinator **101** determines an absolute position based on the absolute position values Pabs and the relative position values Pinc at a plurality of positions. A method of determining the absolute position by the ABS determinator **101** is described later.

Next, the internal configuration and the output signals of the ABS sensor **104** are described below.

FIG. **2** is a sectional view of the ABS sensor **104**. in FIG. **2**, a movable member **21** is a movable portion capable of moving in an X-axis direction which is vertical to a paper plane. A fixed member **22** is a member which serves as a reference of the absolute position of the movable member **21**. A light source **201** is a light emitting unit, and is, for example, an LED. A scale unit **202** is a scale unit including two pattern arrays **203***a* and **203***b* having different numbers of slits provided at equal intervals over a total length. A light receiver **204***a* is a light receiver for receiving light which is emitted from the light source **201** and reflected by the pattern array **203***a*. Similarly, a light receiver **204***b* is a light receiver for receiving light which is emitted from the light source **201** and reflected by the pattern array **203***b*. The light receivers **204***a* and **204***b* are, for example, photodiode arrays. A signal processing circuit **205** is a signal processing circuit for outputting a signal corresponding to any one of the pattern arrays **203***a* and **203***b* in accordance with a switch-over signal from the scale switcher **103**. In this embodiment, the configuration in which the scale unit **202** is provided to the movable member **21** and the light source **201** and the light receivers **204***a* and **204***b* are provided to the fixed member **22** is exemplified. However, the configuration is not limited thereto. The scale unit **202** only needs to foe provided to one of the fixed member **21** and the movable member **22**, whereas the light source **201** and the light receivers **204***a* and **204***b* only need to be provided to the other of the fixed member **21** and the movable member **22**. The same also applies to an embodiment described later.

FIG. **3** is a plan view of the scale unit **202** according to the first embodiment. In FIG. **3**, reflective type slit pattern arrays (reflective pattern arrays) are illustrated as an example. The scale unit **202** includes two pattern arrays, that is, the first pattern **203***a* and the second pattern **203***b*. The scale unit **202** is configured as follows. When the light emitted from the light source **201** enters reflective portions (black portions) of the pattern arrays **203***a* and **203***b*, the light is reflected to the respective light receivers **204***a* and **204***b*. The reflective portions of the first pattern **203***a* are formed at equal pitches P**1**. The reflective portions of the second pattern **203***b* are formed at equal pitches P**2**. In this embodiment, the pitch PI is determined so that forty reflective portions are formed over a total length Lmax of the scale, that is, to have forty cycles over the total length Lmax. The pitch P**2** is determined so that thirty-nine reflective portions are formed over the total length Lmax of the scale, that is, to have thirty-nine cycles over the total length Lmax.

FIG. **4** is a plan view of the light receiver **204***a*. The light receiver **204***b* has the same configuration as that of the light receiver **204***a*. Sixteen photodiodes **401** to **416** are arranged on the light receiver **204***a* at equal intervals in a horizontal direction. The photodiodes **401**, **405**, **409**, and **413** are electrically connected to each other. A group formed by the photodiodes **401**, **405**, **409**, and **413** is referred to as "phase a". A group formed by the photodiodes **402**, **406**, **410**, and **414** is referred to as "phase b". Similarly, a group formed by the photodiodes **403**, **407**, **411**, and **415** is referred to as "phase c", and a group formed by the photodiodes **404**, **408**, 412, and 416 is referred to as "phase d". This embodiment is described based on the presupposition that a length for four photodiodes included in the light receiver **204***a* in a direction of arrangement of the photodiodes (for example, a distance from an end of the photodiode **401** to an end of the photodiode **404**) is twice as large as the pitch P**1** of the reflective portions of the first pattern **203***a*. An optical path length of light which is emitted from the light source **201** to the light receiver **204***a* becomes twice as large as an optical path length of light which is emitted from the light source **201** and reflected by the reflective portions of the first pattern **203***a*. Therefore, a width of the reflected light received by the light receiver **204***a* is twice as large as the width at the reflective portion. Therefore, the width for the four photodiodes included in the light receiver **204***a* corresponds to one cycle of the pattern of the first pattern **203***a*. Thus, the area of pattern arrays that can be read over a total length Is of the photodiodes of the light receiver **204***a* corresponds to four pattern cycles of the first pattern **203***a*.

When the light from the light source **201**, which is reflected by the first pattern **203***a*, is received by the light receiver **204***a*, the phase-a, phase-b, phase-c, and phase-d photo-diode groups respectively output photo-electric currents corresponding to the received light amounts. With the movement of the scale unit **202** in the X-axis direction, the phase-a, phase-b, phase-c, and phase-d photodiode groups output the currents fluctuating in the following phase relationships. Specifically, with respect to the current in the phase a as a reference, the current fluctuates at 90°for the phase b, at 180° for the phase c, and at 270° for the phase d. The signal processing circuit **205** converts the output currents into voltages by a current-voltage converter. Next, the signal processing circuit **205** obtains a differential component between the phase a and the phase c and a differential component between the phase b and the phase d by a differential amplifier. Next, the signal processing circuit **205** generates, from the differential component between the phase a and the phase c and the differential component between the phase b and the phase d, a first A-phase displacement signal S**1**rA which is a A-phase displacement signal of the first pattern **203***a* and a first B-phase displacement signal S**1**rB which is a B-phase displacement signal thereof whose phase is shifted by 90° from the phase of the first A-phase displacement signal S**1**rA. In a similar manner, for the light received by the light receiver **204***b*, a second A-phase displacement signal S**2**rA and a second B-phase displacement signal S**2**rB which are respectively an A-phase displacement signal and a B-phase displacement signal of the second pattern **203***b* to are also generated.

The signal processing circuit **205** outputs any one of a set of the first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB and a set of the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB in accordance with a switch-over signal from the scale switcher **103**.

As described above, the ABS sensor **104** outputs any one of the set of the first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB and the set of the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB in accordance with the switch-over signal from the scale switcher **103**.

Next, the methods of calculating the absolute position and the relative position are described.

The absolute position and the relative position are calculated by the ABS/INC calculator **102**. FIG. **5** illustrates a flow of the absolute position calculation. In Step S**501**, the processing starts. Then, the processing proceeds to Step S**502**.

In Step S**502**, the first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB are corrected.

The first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB or the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB have different signal offsets or signal amplitudes in some cases. If the signals having different signal offsets or signal amplitudes are directly used for the absolute position calculation, an error may be generated in the calculated absolute position Pabs. Therefore, the signals are required to be corrected.

In this embodiment, as described above, the length for the four photodiodes included in the light receiver **204***a* in the direction of arrangement of the photodiodes (for example, the distance from the end of the photodiode **401** to the end of the photo-diode **404**) is twice as large as the pitch P**1** of the reflective portions of the first pattern **203***a*. Therefore, the first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB are respectively expressed as Expressions (1) and (2) below.

$$S1rA:\ a1\times\cos\theta+s1 \tag{1}$$

$$S1rB:\ a2\times\sin\theta+s2 \tag{2}$$

In Expressions (1) and (2), symbol a**1** is an amplitude of the first A-phase displacement signal S**1**rA and symbol s**1** is an offset of the first A-phase displacement signal, symbol a**2** is an amplitude of the first B-phase displacement signal S**1**rB and symbol s**2** is an offset of the first B-phase displacement signal, and symbol θ is a phase of the signal. The first A-phase displacement signal S**1**rA has a maximum value of s**1**+a**1**, a minimum value of s**1**−a**1**, the signal amplitude of a**1**, and an average value of s**1**. Similarly, the second B-phase displacement signal S**1**rB has a maximum value of s**2**+a**2**, a minimum value of s**2**−a**2**, the signal amplitude of a**2**, and an average value of s**2**. By using the values described above, the first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB respectively expressed by Expressions (1) and (2) are corrected. Then, a corrected first A-phase displacement signal S**1**cA and a corrected first B-phase displacement signal S**1**cB are expressed as Expressions (3) and (4) below.

$$S1cA:\ \{(a1\times\cos\theta+s1)-s1\}\times a2=a1\times a2\times\cos\theta \tag{3}$$

$$S1cB:\ \{(a2\times\sin\theta+s2)-s2\}\times a1=a1\times a2\times\sin\theta \tag{4}$$

As a result, the offsets of the first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB are removed to obtain the first A-phase displacement signal S**1**cA and the first B-phase displacement signal S**1**cB having the same signal amplitude.

After the first A-phase displacement signal S**1**rA and the first B-phase displacement signal S**1**rB are corrected in Step S**502** by the processing described above, the processing proceeds to Step S**503**.

In Step S**503**, by using the corrected first A-phase displacement signal S**1**cA and the corrected first B-phase displacement signal S**1**cB, an arctangent calculation is performed to calculate a signal Atan**1** as shown in FIG. **6**A. The first pattern **203***a* is a pattern which has forty cycles over the total length Lmax of the scale. Therefore, the signal Atan**1** has eighty cycles over the total length of the scale. Next, the first relative position signal Inc**1** having forty cycles over the total length of the scale and the wave height Vmax is calculated from the signal Atan**1**. Specifically, a gain is applied to the signal Atan**1** so that the wave height of the signal Atan**1** becomes Vmax/2. The signal level is offset so that the signal level becomes G when the phase of the first B-phase displacement signal S**1**rB is at 0°. Then, by adding Vmax/2 when the phase is in the range from 180°to 360°, the first relative position signal Inc**1** is calculated. Therefore, the first relative position signal Inc**1** becomes a saw tooth wave having forty cycles over the total length Lmax of the scale, as shown in FIG. **6**B. Accordingly, the first relative position signal Inc**1** corresponding to the phase of the first pattern **203***a* having the pitch P**1** in one-by-one fashion is calculated by the ABS/INC calculator **102** (phase calculator).

In this case, each horizontal axis of FIGS. **6**A, **6**B, **6**C, and **6**D represents a position of the scale with respect to the total length Lmax, and each vertical axis thereof represents a signal level at that time.

After the first relative position signal Inc**1** is calculated in Step **S503**, the processing proceeds to Step **S504**.

In Step **S504**, the second A-phase displacement signal S**2**rA and the first B-phase displacement signal S**2**rB are corrected.

The light receiver **204***b* has the same configuration as the light receiver **204***a*. Therefore, the length for four photodiodes included in the light receiver **204***b* in the direction of arrangement of the photodiodes (for example, the distance from the end of the photodiode **401** to the end of the photodiode **404**) is twice as large as the pitch P**1** of the reflective portions of the first pattern **203***a*. The pitch P**1** of the reflective portions of the first pattern **203***a* and the pitch P**2** of the reflective portions of the second pattern **203***b* are different from each other. Therefore, the length for four photodiodes included in the light receiver **204***b* in the direction of arrangement of the photodiodes (for example, the distance from the end of the photodiode **401** to the end of the photodiode **404**) does not become twice as large as the pitch P**2** of the reflective portions of the second pattern **203***b*. Therefore, the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB have a relationship in which the phase shift therebetween is not 90°.

Thus, the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB are respectively expressed by Expressions (5) and (6) below.

$$S2rA:\ b1\times\cos\theta+t1 \tag{5}$$

$$S2rB:\ b2\times\sin(\theta+\alpha)+t2 \tag{5}$$

In Expressions (5) and (6), symbol b**1** is an amplitude of the second A-phase displacement signal S**2**rA and symbol t**1** is an offset of the second A-phase displacement signal S**2**rA, symbol b**2** is an amplitude of the second B-phase displacement signal S**2**rB and symbol t**2** is an offset of the second B-phase displacement signal S**2**rB, symbol θ is a phase of the signal, and symbol α is a shift amount of the phase. When the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB are corrected in the same manner as in the processing performed in Step **S502**, a corrected second A-phase displacement signal S**2**cA' and a corrected second B-phase displacement signal S**2**cB' are expressed by Expressions (7) and (8) below.

$$S2cA':\{(b1\times\cos\theta+t1)-t1\}\times b2=b1\times b2\times\cos\theta \tag{7}$$

$$S2cB':\{(b2\times\sin(\theta+\alpha)+t2)-t2\}\times b1=b1\times b2\times\sin(\theta+\alpha) \tag{8}$$

As a result, the offset t**1** of the second A-phase displacement signal S**2**rA and the offset t**2** of the second B-phase displacement signal S**2**rB are removed to obtain the second A-phase displacement signal S**2**cA' and the second B-phase displacement signal S**2**cB' having the same signal amplitude.

Next, processing for setting a phase difference between the second. A-phase displacement signal S**2**cA' and the second B-phase displacement signal S**2**cB' to 90° by using Expressions (7) and (8) is described below.

A difference between Expressions (7) and (8) and the sum of Expressions (7) and (8) are respectively expressed by Expressions (9) and (10) below.

$$b1\times b2\times(\sin(\theta+\alpha)-\cos\theta)=b1\times b2\times 2\times\sin\{(\alpha+90)/2\}\times\cos\{\theta+(\alpha+90)/2\} \tag{9}$$

$$b1\times b2\times(\sin(\theta+\alpha)-\cos\theta)=b1\times b2\times 2\times\cos\{(\alpha+90)/2\}\times\sin\{\theta+(\alpha+90)/2\} \tag{10}$$

The phase difference given by Expressions (9) and (10) becomes 90° by the calculations described above.

The amplitudes in Expressions (9) and (10) are different from each other. Therefore, the amplitudes are next corrected to calculate a second A-phase displacement signal S**2**cA and a second B-phase displacement signal S**2**cB having the same signal amplitude. Expression (9) is multiplied by cos{(α−90)/2} which is a part of the amplitude in Expression (10), and Expression (10) is multiplied by sin{(α−90)/2} which is a part of the amplitude in Expression (9). Then, Expressions (11) and (12) are obtained.

$$S2cA=b1\times b2\times 2\times\sin\{(\alpha+90)/2\}\times\cos\{(\alpha-90)/2\}\times\cos\{\theta+(\alpha+90)/2\} \tag{11}$$

$$S2cB=b1\times b2\times 2\times\sin\{(\alpha+90)/2\}\times\cos\{(\alpha-90)/2\}\times\sin\{\theta+(\alpha+90)/2\} \tag{12}$$

As a result, the offsets of the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB are removed so that the second A-phase displacement signal S**2**cA and the second B-phase displacement signal S**2**cB having the same signal amplitude are obtained.

After the second A-phase displacement signal S**2**rA and the second B-phase displacement signal S**2**rB are corrected In Step **S504** by the processing described above, the processing proceeds to Step **S505**.

In Step **S505**, the same calculation as that performed in Step **S503** is performed using the corrected second A-phase displacement signal S**2**cA and the corrected second B-phase displacement signal S**2**cB to calculate a second relative position signal Inc**2**. The second pattern **203***b* is a pattern array having thirty-nine cycles over the total length Lmax of the scale. Therefore, the second relative position signal Inc**2** becomes a saw tooth wave having thirty-nine cycles over the total length Lmax of the scale, as shown in FIG. **6**C. Accordingly, the second relative position signal Inc**2** corresponding to the phase of the second pattern **203***b* having the pitch P**2** in one-by-one fashion is calculated by the ABS/INC calculator **102** (phase calculator). The horizontal axis of FIGS. **6**A, **6**B, **6**C, and **6**D indicates the position on the total length Lmax of the scale, whereas the vertical axis indicates the signal level at the position.

After the second relative position signal Inc**2** is calculated in Step **S505**, the processing proceeds to Step **S506**.

In Step **S506**, a difference between the first relative position signal Inc**1** and the second relative position signal Inc**2** is calculated, and when the difference is a negative value, Vmax is added, to thereby obtain a Vernier signal Pv**1** is obtained as shown in FIG. **6**D. In this case, the difference in cycle with respect to the total length Lmax between the first relative position signal Inc1 and the second relative position signal Inc2 is 1, and hence the Vernier signal Pv1 becomes a saw tooth wave of one cycle with respect to the total length Lmax.

After the Vernier signal Pv1 is calculated in Step S506, the processing proceeds to Step S507.

In Step S507, the absolute position value Pabs is calculated.

The signals S1rA, S1rB, S2rA, and S2rB each contain a noise component due to a disturbance and the like. Therefore, the first and second relative position signals Inc1 and Inc2 calculated from the signals S1rA, S1rB, S2rA, and S2rB also contain a noise component. The first relative position signal Inc1 and the second relative position signal Inc2 are not based on the signals S1rA, S1rB, S2rA, and S2rB that are obtained simultaneously, and hence there is a signal obtaining delay. In the case where the movable member 21 is moving during the signal obtaining delay time, a phase shift occurs in a signal. In order to correct an error component E caused by a noise component and a phase shift amount, the synchronism calculation of the Vernier signal Pv1 and the first relative position signal Inc1 is performed. As a result of the synchronism calculation, a signal synthesized through use of the Vernier signal Pv1 which is an upper-level signal and the first relative position signal inc1 which is a lower-level signal is calculated as a signal level Vabs representing the absolute position. The absolute position value Pabs is calculated from the signal level Vabs. A method of calculating the absolute position value Pabs from the signal level Vans is described later.

FIGS. 7A, 7B, 7C, and 7D show how the waveforms change by the synchronism calculation described above.

In FIGS. 7A, 7B, 7C, and 7D, the horizontal axis indicates the position on the total length Lmax of the scale, whereas the vertical axis indicates the signal level at the position on the total length Lmax. In addition, symbol Visas indicates the maximum value of the signal level, and symbol N1 indicates a cycle number of a region from a start point of the scale. The maximum cycle is defined as N1max. In this embodiment, the first pattern 203*a* has forty cycles over the total length Lmax of the scale. Therefore, N1max is 40, where N1 is a natural number ranging from 1 to 40.

FIG. 7A shows waveforms of Inc1, Pv1, and Inc1/N1max. When a difference between the waveform of Pv1 and Inc1/N1max having the same gradient as Pv1 is taken, a step-like waveform containing the error component E shown in FIG. 7B is generated. A signal Vb' having the waveform shown in FIG. 7B is expressed by Expression (13). A signal level for one step of the step-like waveform is Vmax/N1max.

$$Vb'=Pv1-(Inc1/N1max) \tag{13}$$

Next, the error component E of the waveform shown in FIG. 7B is removed by rounding. Then, a waveform shown in FIG. 7C is obtained. A signal Vb having the waveform shown in FIG. 7C is expressed by Expression (14).

$$Vb-Round[\{Pv1-(Inc1/N1max)\}\times(N1max/Vmax)]\times(Vmax/N1max) \tag{14}$$

where Round[] is a function for rounding off the first decimal place.

The error component E can be expressed by Expression (15).

$$E=[Pv1-(Inc1/N1max)]-Vb \tag{15}$$

The waveform of Inc1/N1max is added to the waveform of the signal Vb shown in FIG. 7C to generate the signal Vabs indicating the absolute position obtained by removing the error component E, as shown in FIG. 7D.

The synchronism calculation is performed by a calculation expressed by Expression (16).

$$Vabs=Vb+(Inc1/N1max) \tag{16}$$

From the signal level Vabs indicating the absolute position, the absolute position value Pabs is expressed by Expression (17).

$$Pabs=Vabs\times(Lmax/Vmax) \tag{17}$$

After the absolute position value Pabs is calculated in Step S507, the processing proceeds to Step S508 and ends.

The absolute position value Pabs can be calculated as described above.

After she absolute position value Pabs is once obtained through the above-mentioned processing flow, in order to obtain a relative position, the ABS/INC calculator 102 instructs the scale switcher 103 to output the first A-phase displacement signal S1rA and the first B-phase displacement signal S1rB. In general, the relative position can be obtained, for example, by an incremental encoder or the like. In this case, the resolution is determined based on the fineness of a pulse to be generated (fineness of a read pattern). In the present invention, a phase in a pulse cycle can be obtained in addition to a pulse count through use of the first relative position signal Inc1 that is a periodic signal, and hence the position in a pulse cycle can also be specified. The ABS/INC calculator 102 calculates the first relative position signal Inc1 by the above-mentioned method based on the first A-phase displacement signal S1rA and the first B-phase displacement signal S1rB, and periodically calculates the relative position value Pinc based on the values of the relative position signal Inc1 and the first relative position signal Inc1 used in the calculation of the absolute position value Pabs in Expression (17). The relative position value Pinc that is a relative displacement amount based on the absolute position value Pabs is expressed by Expression (18).

$$Pinc=\{(Inc1\_current-Inc1\_base)/Vmax+N\_Inc1\}\times Lmax/N1max \tag{13}$$

where Inc1_base represents the first relative position signal Inc1 at a time of calculation of the absolute position value Pabs, Inc1_current represents the first relative position signal Inc1 at a time of calculation of the relative position; and N_Inc1 represents the accumulation of number of times by which the first relative position signal Inc1 is switched between Vmax and 0 (number of pulses) (note that, the number of times of switching from Vmax to 0 is defined to be positive, and the number of times of switching from 0 to Vmax is defined to be negative).

Accordingly, the ABS/INC calculator 102 always calculates the relative position value Pinc, except for the time period during which the absolute position value Pabs is calculated. Note that, in this embodiment, the calculation of the relative position value using the first relative position signal Inc1 has been described, but the present invention is not limited thereto. The relative position measured by any method can be applied to the present invention as long as the method is capable of measuring a known relative position.

Next, a method of determining an absolute position by the ABS determinator 101 is described.

FIGS. 8A, 8B, and 8C each illustrate a pattern read area 801 at a certain absolute position and the state of a foreign matter 802 on the scale unit 202 on a plan view of the scale unit 202 in this embodiment. In this embodiment, the pattern read area **801** corresponds to four cycles of the pattern of the pattern array **203***a*, and hence a width Lps of the pattern read area **801** in the X-direction is a length of P1×4. FIG. **8**A illustrates the state in which the foreign matter **802** borders on the pattern read area **801** and the foreign matter **802** is not present in the pattern read area **801**. FIG. **8**B illustrates the state in which the foreign matter **802** is present in the pattern read area **801**. FIG. **8**C illustrates the state in which the foreign matter **802** borders on the pattern read area **801** on the opposite side of FIG. **8**A and the foreign matter **802** is not present in the pattern read area **801**. The movement amount of the pattern read area **801** of FIGS. **8**A, **8**B, and **8**C is defined as Lms. In the case where the movable member **21** is movable in the X-direction, and the pattern read area **801** moves in the order of FIGS. **8**A, **8**B, and **8**C, the light received by the light receiver **204***a* of FIG. **4** is influenced by the foreign matter **802** in the movement range of the movement amount Lms in the pattern read area **801**. As a result, a signal in a correct pattern is not read, and a malfunction is caused in which the absolute position value Pabs cannot be calculated correctly. In this case, when the width of the foreign matter **802** in the X-axis direction (length of an error occurring range in the movement direction) is defined, as Lpd, the movement amount Lms is expressed by Expression (19).

$$Lms=Lps+Lpd \tag{19}$$

Thus, in the case where the foreign matter **802** is present at any position in the pattern read area **801** at a certain absolute position, the foreign matter **802** is not present in the pattern read area **801** at the absolute position moved by the movement amount Lms or more. That is, the absolute position value Pabs at any one of the two absolute positions that are away from each other by the movement amount Lms or more is not influenced by the foreign matter **802**, and thus the correct absolute position value Pabs is calculated.

In this case, when the width of an allowable foreign matter in the X-axis direction is defined as Lpdmax, a minimum movement amount (error recovering displacement amount) Lmsmin required for moving the absolute position to a position that is not influenced by the foreign matter **802** without fail can be set by Expression (20).

$$Lmsmin=Lps+Lpdmax \tag{20}$$

The maximum value Lpdmax of the width of the allowable foreign matter in the X-axis direction is determined in advance based on the size of the maximum foreign matter to be mixed during the manufacturing of an absolute encoder, and the minimum movement amount Lmsmin corresponding thereto is held by the ABS determinator **101**.

Accordingly, if the difference between the absolute position values (first temporal position and second temporal position) Pabs and the difference (displacement amount) between the relative position values Pinc at two positions that are away from each other by the minimum movement amount Lmsmin are matched with each other, it can be determined that any absolute position value Pabs at two absolute positions is calculated correctly. Further, if the difference between the absolute position values Pabs (first temporal position and second temporal position) and the difference (displacement amount) between the relative position values Pinc at certain two positions are not matched with each other (in other words, if it is determined they are different from each other), the absolute position value Pabs (third temporal position) is calculated at a position away from any one of the two positions by the minimum movement amount Lmsmin or more. It can be determined that the absolute position values Pabs at two positions where the difference between the absolute position values Pabs (temporal positions) and the difference (displacement amount) between the relative position values Fine among combinations of the three absolute positions are matched with each other are both calculated correctly.

FIG. **9** illustrates a flow of absolute position determination in this embodiment.

The absolute position value is determined by the ABS determinator **101**.

In Step **S901**, processing starts and then proceeds to Step **S902**.

In Step **S902**, a relative position value Pincc is initialized, and the processing proceeds to Step **S903**. In the following, the absolute position in Step **S902** is defined as an initial position of a relative position, and the relative position value Pincc is updated as a relative position displacement amount from the initial position. The processing proceeds to Step **S903**.

In Step **S903**, the present relative position value Pincc is held as a relative position value Pinc**1** at a present position (position **1**), and the processing proceeds to Step **S904**.

In Step **S904**, the absolute position value Pabs at the present position (position **1**) is calculated, and the calculated absolute position value Pans is held as an absolute position value Pabs**1**. Then, the processing proceeds to Step **S906**.

In Step **S905**, the relative position value Pincc at the present position is updated, and the processing proceeds to Step **S906**.

In Step **S906**, when it is determined based on the updated relative position value Pincc that the movable member has not moved from the position **1** or an absolute position value Pabsc calculation position (described later) by a predetermined movement amount Mpb, the processing returns to Step **S905**, and otherwise, the processing proceeds to Step **S907**. In this case, the predetermined movement amount Mpb is any value equal to or less than the minimum movement amount Lmsmin.

In Step **S907**, the absolute position value Pabs at the present position is calculated, and the calculated absolute position value Pabs is held as an absolute position value Pabsc'. Then, the processing proceeds to Step **S908**.

In Step **S908**, when the difference between the absolute position value Pabsc' at the present position and the absolute position value Pabs**1** at the position **1** is matched with the difference between the relative position value Pincc at the present position and the relative position value Pinc**1** at the position **1**, the processing proceeds to Step **S909**, and otherwise, the processing proceeds to Step **S911**.

In this case, when the difference between the absolute position values and the difference between the relative position values are not matched with each other, it can be determined that an error has occurred in the calculation of the absolute position value at any one of the present position and the position **1**. That is, it can be determined that the foreign matter **802** is present somewhere in the pattern read area **801** at the present position or in the pattern read area **801** at the position **1**.

In Step **S909**, it is determined based on the relative position value Pincc whether or not the present position has moved from the position **1** by the minimum movement amount Lmsmin or more. When the present position has moved by the minimum movement amount Lmsmin or more, the processing proceeds to Step **S910**. When the present position has not moved by the minimum movement amount Lmsmin or more, the processing returns to Step **S905**.

In Step S910, the absolute position value Pabsc' is determined as a reference absolute position value Pabsb because an error has not been detected in the absolute position value Pabs even when the present position has moved by the minimum movement amount Lmsmin or more. Further, the present relative position value Pincc is held as a reference relative position value Pincb, and the processing proceeds to Step S916 and ends.

In Step S911 branched from Step S908, the relative position value Piece at the present position is held as a relative position value Pinc1 at the position 2. Further, the absolute position value Pabsc' at the present position is held as an absolute position value Pabs2 at the position 2, and the processing proceeds to Step S912.

In Step S912, the relative position value Pincc at the present position is updated, and the processing proceeds to Step S913.

In Step S913, the processing proceeds to Step S914 when the difference between the relative position value Pincc and the relative position value Pinc1 is equal to or more than the minimum movement amount Lmsmin and the difference between the relative position value Pincc and the relative position value Pinc1 is equal to or more than the minimum movement amount Lmsmin. When the difference between the relative position value Pincc and the relative position value Pinc1 is equal to or more than the minimum movement amount Lmsmin and the difference between the relative position value Pincc and the relative position value Pinc2 is not equal to or more than the minimum movement amount Lmsmin, the processing returns to Step S912.

In Step S914, the absolute position value Pabs at the present position is calculated, and the calculated absolute position value Pabs is held as the absolute position value Pabsc'. Then, the processing proceeds to Step S915.

In Step S915, it is determined that the present position has moved from the error occurring position by the minimum movement amount Lmsmin or more and is not influenced by the foreign matter 802 based on the pattern read area 801, and the absolute position value Pabsc' is determined as the reference absolute position value Pabsb. Then, the processing proceeds to Step S916.

When the processing proceeds to Step S916, the processing ends.

After that, the present absolute position value Pabsc is determined based on the reference absolute position value Pabsb, the reference relative position value Pincb, and the present relative position value Pincc. The present absolute position value Pabsc is expressed by Expression (21).

$$Pabsc=Pabsb+(Pincc-Pincb) \tag{21}$$

In the position detecting apparatus of this embodiment, when the movable member is moved by a slight amount by any operation immediately after the start-up of the apparatus, an absolute position is determined naturally at that time point.

In this embodiment, in the case where the absolute position value is not matched with the relative position value, the absolute position value Pabs at the absolute position moved by the minimum movement amount Lmsmin or more is determined as the reference absolute position value Pabsb.

However, another method may be used. That is, the mismatch between the absolute position value and the relative position value is checked again, and, when the mismatch occurs, the reference absolute position value Pabsb is not determined until the absolute position value and the relative position value are matched with each other.

Further, the following may also be performed. The absolute position values and the relative position values at a plurality of absolute positions away from each other by the minimum movement amount Lmsmin or more are recorded, and the reference absolute position value may be determined based on the absolute position value at which the match occurs often based on the relationship between the absolute position values and the relative position values at the plurality of absolute positions.

Accordingly, even in the case where motes and scratches are present on the scale in the Vernier type absolute encoder, an absolute position having high reliability can be calculated while erroneous absolute position calculation is prevented.

Further, in this embodiment, an optical encoder has been described. However, the present invention is not limited thereto, and even in a magnetic or electrostatic absolute encoder, the similar effects can be exhibited to those giving external disturbance to the detection of a periodic signal due to defects or the like on the scale in which a periodic pattern is formed in the movement direction.

Second Embodiment

Next, a second embodiment of the present invention is described with reference to FIG. 10.

FIG. 10 is a configuration block diagram of this embodiment, and the same configuration as that of FIG. 1 is denoted by the same reference numeral.

An ABS determinator 1001 is an absolute position determinator for determining the present absolute position Pabsc based on the absolute position value Pabs and the relative position value Pinc calculated by the ABS/INC calculator 102, and is different in operation from the ABS determinator 101 described in the first embodiment. A drive controller 1002 is configured to drive and control a movable member 1004. A motor 1003 is configured to drive the movable member 1004, and examples thereof include a DC motor and a stepping motor. The movable member 1004 is subjected to absolute position detection by the ABS sensor 104.

Next, the operation of this embodiment is described.

FIG. 11 illustrates a flow of absolute position determination in this embodiment.

The absolute position value is determined by the ABS determinator 1001.

In Step S1101, processing starts and then proceeds to Step S1102.

In Step S1102, the relative position value Pincc is initialized, and the processing proceeds to Step S1103, In the following, the absolute position in Step S1102 is defined as an initial position of a relative position, and the relative position value Pincc is updated as a relative position displacement amount from the initial position.

In Step S1103, the present relative position value Pincc is held as the relative position value Pinc1 at the present position (position 1), and the processing proceeds to Step S1104.

In Step S1104, the absolute position value Pabs at the present position (position 1) is calculated. The calculated absolute position value Pabs is held as the absolute position value Pabs1, and the processing proceeds to Step S1105.

In Step S1105, the ABS de terminator 1001 instructs the drive-controller 1002 to drive the movable member 1004 by a predetermined movement amount Mpb, and the processing proceeds to Step S1106. In this case, the predetermined movement amount Mpb is any value equal to or less than the minimum movement amount Lmsmin. The drive controller 1002 controls the motor 1003 in accordance with the instruction and drives the movable member **1004**. The ABS sensor **104** outputs a signal corresponding to the position of the movable member **1004** to the AD converter **105** in accordance with the drive of the movable member **1004**.

In Step S**1106**, the relative position value Pincc at the present position is updated, and the processing proceeds to Step S**1107**.

In Step S**1107**, when it is determined based on the updated relative position value Pincc that the movable member has not moved from the position **1** or an absolute position value Pabsc calculation position (described later) by the predetermined movement amount Mpb, the processing returns to Step S**1106**, and otherwise, the processing proceeds to Step S**1108**.

In Step S**1108**, the absolute position value Pabs at the present position is calculated. The calculated absolute position value Pabs is held as the absolute position value Pabsc'. Then, the processing proceeds to Step S**1109**.

In Step S**1109**, when the difference between the absolute position value Pabsc' at the present position and the absolute position value Pabs**1** at the position **1** is matched with the difference between the relative position value Pincc at the present position and the relative position value Pinc**1** at the position **1**, the processing proceeds to Step S**1110**, and otherwise, the processing proceeds to Step S**1112**.

In Step S**1110**, it is determined based on the relative position value Pincc whether or not the present position has moved from the position **1** by the minimum movement amount Lmsmin or snore. When the present position has moved by the minimum movement amount Lmsmin or more, the processing proceeds to Step S**1111**. When the present position has not moved by the minimum movement amount Lmsmin or more, the processing returns to Step S**1105**.

In Step S**1111**, the absolute position value Pabsc' is determined as the reference absolute position value Pabsb because an error has not been detected in the absolute position value Pabs even when the present position has moved by the minimum movement amount Lmsmin or more. Further, the present relative position value Pincc is held as the reference relative position value Pincb, and the processing proceeds to Step S**1118**.

In Step S**1112**, the relative position value Pincc at the present position is held as the relative position value Pinc**2** at the position **2**. Further, the absolute position value Pabsc' at the present position is held as the absolute position value Pabs**2** at the position **2**, and the processing proceeds to Step S**1113**.

In step S**1113**, the ABS determinator **1001** instructs the drive controller **1002** to drive the movable member **1004** by the minimum movement amount Lmsmin, and the processing proceeds to Step S**1114**.

In Step S**1114**, the relative position value Pincc at the present position is updated, and the processing proceeds to Step S**1115**.

In Step S**1115**, when the difference between the relative position value Pincc and the relative position value Pinc**1** is equal to or more than the minimum movement amount Lmsmin and the difference between the relative position value Pincc and the relative position value Pinc**2** is equal to or more than the minimum movement amount Lmsmin, the processing proceeds to Step S**1116**. The difference between the relative position value Pincc and the relative position value Pinc**1** is equal to or more than the minimum movement amount Lmsmin and the difference between the relative position value Pincc and the relative position value Pinc**2** is not equal to or more than the minimum movement amount Lmsmin, the processing returns to Step S**1114**.

In Step S**1116**, the absolute position value Pabs at the present position is calculated. The calculated absolute position value Pabs is held as the absolute position value Pabsc'. Then, the processing proceeds to Step S**1117**.

In Step S**1117**, it is determined that the present position has moved from the error occurring position by the minimum movement amount Lmsmin or more and is not influenced by the foreign matter **802** based on the pattern read area **801**, and the absolute position value Pabsc' is determined as the reference absolute position value Pabsb. Then, the processing proceeds to Step S**1118**.

In Step S**1118**, the ABS determinator **1001** instructs the drive controller **1002** to drive the movable member **1004** to the relative position value Pinc**1** that is the initial position, and the processing proceeds to Stop S**1119**.

In Step S**1119**, the relative position value Pincc at the present position is updated, and the processing proceeds to Step S**1120**.

In Step S**1120**, when the relative position value Pincc is matched with the relative position value Pinc**1**, the processing proceeds to Step S**1121** and ends. When the relative position value Pincc is not matched with the relative position value Pinc**1**, the processing returns to Step S**1119**.

After that, by the same method as that of the first embodiment, the present absolute position value Pabsc is determined based on the reference absolute position value Pabsb, the reference relative position value Pincb, and the present relative position value Pincc.

In the above-mentioned processing flow, the absolute position is determined at a time of proceeding to Step S**1118**. In this embodiment, the movable member **1004** is forcedly moved so as to determine the absolute position, and hence the processing from Step S**1118** to Step S**1120** is the processing for returning to the state before the start of the processing flow. A unit for storing the relative position value immediately after the start of the processing flow of FIG. **11** may be provided for the above-mentioned purpose. In this embodiment, in the case where the absolute position value is not matched with the relative position value, the absolute position value Pabs at the absolute position moved by the minimum movement amount Lmsmin or more is determined as the reference absolute position value Pabsb.

However, another method may be used. That is, the mismatch between the absolute position value and the relative position value is checked again, and, when the mismatch occurs, the movable member **1004** is driven by the minimum movement amount Lmsmin or more again, and the reference absolute position Pabsb is not determined until the absolute position value and the relative position value are matched with each other.

Further, the following may also be performed. The movable member **1004** is driven to a plurality of positions that are away from each other by the minimum movement amount Lmsmin or more, and the absolute position value and the relative position value at each position are calculated. After that, a reference absolute position value may be determined based on the absolute position value at which the match occurs often based on the relationship between the absolute position values and the relative position values at the plurality of absolute positions.

Accordingly, even in the case where motes and scratches are present on the scale in the Vernier type absolute encoder, an absolute position having high reliability can be calculated while erroneous absolute position calculation is prevented through the minimum drive at the time of the initial start-up.

Further, in the above-mentioned embodiment, the use of an optical encoder has been exemplified. However, the present invention is not limited thereto, and a magnetic or electrostatic absolute encoder may be used.

A lens apparatus capable of exhibiting the effect of the present invention can be realized by applying the position detecting apparatus of the embodiments to a lens apparatus including a movable optical member so as to detect the position of the movable optical member. Further, an image pickup apparatus capable of exhibiting the effect of the present invention can be realized by applying the position detecting apparatus of the embodiments to an image pickup apparatus including a lens apparatus including a movable optical member and a camera apparatus so as to detect the position of the movable optical member.

Other Embodiments

Embodiment(s) of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiment(s) and/or that includes one or mere circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiment(s), and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s) and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2013-224847, filed Oct. 30, 2013, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. A position detecting apparatus, comprising:

a seals comprising a plurality of pattern arrays formed in different cycles in a movement direction;

an obtaining unit configured to obtain a plurality of signals in accordance with the plurality of pattern arrays;

a first deriving unit configured to derive a temporal position of the scale with respect to the obtaining unit, based on the plurality of signals;

a second deriving unit configured to derive a displacement amount of the scale with respect to the obtaining unit based on one or more signals of the plurality of signals; and

a determinator configured to determine a determined position of the scale with respect to the obtaining unit based on the temporal position and the displacement amount,

wherein the determinator determines the determined position based on a result of comparison between a difference between a first temporal position calculated by the first deriving unit at a first position and a second temporal position calculated by the first deriving unit at a second position and a displacement amount derived by the second deriving unit from the first position to the second position.

2. A position detecting apparatus according to claim **1**, wherein, when the determinator determines that the difference and the displacement amount are different from each other, there is an error in any one of the first absolute position value and the second absolute position value based on the first absolute position value, the second absolute position value, and the displacement amount calculated by the relative position calculator from the first position to the second position, the determinator determines she determined position based on a third temporal position derived by the first deriving unit at a third position that is different from the first position and the second position, the first temporal position, the second temporal position, and the displacement amount between any two positions of the first position, the second position, and the third position calculated by the second deriving unit.

3. A position detecting apparatus according to claim **1**, wherein the error amount is larger than a predetermined value which is set based on a length of the scale in the movement direction in which the obtaining unit is capable of obtaining the plurality of signals simultaneously.

4. A position detecting apparatus according to claim **1**, wherein the error amount is larger than a predetermined value which is set based on a length of a predefined error occurring range in the movement direction on the scale.

5. A position detecting apparatus according to claim **1**, further comprising a controller configured to control drive of the scale in the movement direction with respect to the obtaining unit,

wherein the controller drives the scale in the movement direction until the determinator determines the determined position.

6. A position detecting apparatus according to claim **5**, further comprising a unit configured to store the displacement amount derived by the second deriving unit at a time when the determinator starts processing of determining the determined position,

wherein the controller drives the scale up to a position corresponding to the stored displacement amount after the determinator determines the determined position.

7. A position detecting apparatus according to claim **1**,

wherein the plurality of pattern arrays comprises a plurality of reflective pattern arrays, and

wherein the obtaining unit comprises a light source and a plurality of light receivers configured to receive each light emitted from the light source and reflected by the plurality of reflective pattern arrays.

8. A lens apparatus, comprising:

a movable optical member; and

a position detecting apparatus serving as a position detecting apparatus for the movable optical member, the position detecting apparatus, comprising:

a scale comprising a plurality of pattern arrays formed in different cycles in a movement direction;

an obtaining unit configured to obtain a plurality of signals in accordance with the plurality of pattern arrays;

a first deriving unit configured to derive a temporal position of the scale with respect to the obtaining, based on the plurality of signals;

a second deriving unit configured to derive a displacement amount of the scale with respect to the obtaining unit based on one or more signals of the plurality of signals; and

a determinator configured to determine a determined position of the scale with respect to the obtaining unit based on the temporal position and the displacement amount,

wherein the determinator determines the determined position based on a result of comparison between a difference between a first temporal position calculated by the first deriving unit at a first position and a second temporal position calculated by the first deriving unit at a second position and a displacement amount derived by the second deriving unit from the first position to the second position.

9. An image pickup apparatus, comprising:

a lens apparatus comprising;

a movable optical member; and

a position detecting apparatus serving as a position detecting apparatus for the movable optical member, the position detecting apparatus, comprising:

a scale comprising a plurality of pattern arrays formed in different cycles in a movement direction;

an obtaining unit configured to obtain a plurality of signals in accordance with the plurality of pattern arrays;

a first deriving unit configured to derive a temporal position of the scale with respect to the obtaining unit, based on the plurality of signals;

a second deriving unit configured to derive a displacement amount of the scale with respect to the obtaining unit based on one or more signals of the plurality of signals; and

a determinator configured to determine a determined position of the scale with respect to the obtaining unit based on the temporal position and the displacement amount,

wherein the determinator determines the determined position based on a result of comparison between a difference between a first temporal position calculated by the first deriving unit at a first position and a second temporal position calculated by the first deriving unit at a second position and a displacement amount derived by the second deriving unit from the first position to the second position; and

a camera apparatus.

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